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AUTHOR	Sherrill, Donna; Tibbs, Peggy
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ABSTRACT

This paper presents two mathematics activities that model functions studied using the Calculator Based Ranger (CBR) software for TI-82 and TI-83 graphing calculators. The activities concern a bouncing ball experiment and modeling a decaying exponential function. (ASK)

MODELING FUNCTIONS WITH THE CALCULATOR BASED RANGER

I. THE BOUNCING BALL EXPERIMENT
II. MODELING A DECAYING EXPONENTIAL FUNCTION USING THE CBR

PRESENTED BY:
DONNA SHERRILL
PEGGY TIBBS

ARKANSAS TECH UNIVERSITY
RUSSELLVILLE, ARKANSAS

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THE BOUNCING BALL EXPERIMENT

According to Physics textbooks, when a ball is bounced, its height is a function of time. The type of function is quadratic. We are going to test this hypothesis using the CBR. All we need is one clear bounce.

Equipment:
CBR, TI-82 or TI-83 Calculator, Ball, Linking Cord

Procedure:
1. Check the calculator you plan to use to see if it has at least 17,500 bytes of memory available.
   2nd MEM #1 Check RAM
   If you do not have enough memory free then save your programs to another calculator, then press 2nd MEM #5 Reset This deletes all of your programs. They can be given back after the experiment if you save them to another calculator.
2. Connect your calculator to the CBR with the linking cord.
3. Press 2nd LINK; RECEIVE; ENTER.
4. Open the pivoting head on the CBR and press the button that says 82/83.
5. When the transfer is complete, the calculator will say Ranger Prgm; Done.
6. Run the RANGER program.
7. When Main Menu is displayed, choose APPLICATIONS.
8. For Units choose FEET.
9. Under APPLICATIONS, choose #3; BALL BOUNCE.
   Follow directions on the screen.
   If the ball bounces away from the person holding the CBR, follow it but be careful to keep the CBR at the same height.
   After CBR is finished recording the data, hit ENTER. You will see the message: Transferring... You will then see the graph on the calculator screen. An example of a satisfactory graph is shown below in figure 1. Remember you only need one good bounce. If the graph is not satisfactory, hit ENTER again, then #5: REPEAT SAMPLE.

10. Hit ENTER, which will take you to PLOT MENU. Choose #4: PLOT TOOLS. Choose SELECT DOMAIN. Set your left bound and right bound on either side of the one good bounce shown on the graph by moving the cursor and pressing ENTER. The calculator will say "Analyzing..." and then will show just the part of the graph you have selected. See figure 2 below. The coordinates of the points of this graph are stored in L_1 and L_2 where L_1 is time and L_2 is distance.

Figure 1

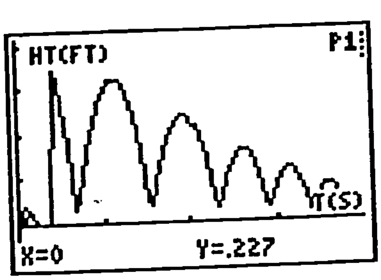
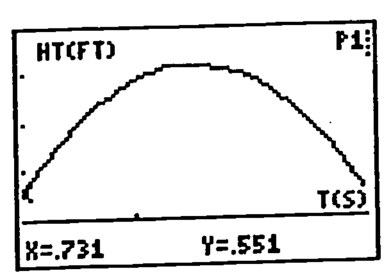


Figure 2



11. Hit ENTER which will take you back to MAIN MENU. Select #7: QUIT. The calculator should say "done."

12. Find the best fit quadratic equation by pressing STAT; CALC ; QUADREG; ENTER. L1 is time and L2 is distance. Record your equation by rounding the coefficients to two decimal places ______________________________

See figure 3 for the regression equation for the example graphs on the previous page.

```
QuadReg
 y=ax²+bx+c
 a=-16.10642685
 b=36.65031938
 c=-17.63409774
 R²=.9999345565
```

Figure 3

13. Go to Y= on your calculator and enter this equation for Y1. Since the calculator will not give a value for r, the correlation coefficient, compare with the graph to see if it is a good fit. (Note: The TI-83 will tell you the value if r^2 . You can take the square root of this number to find r.)

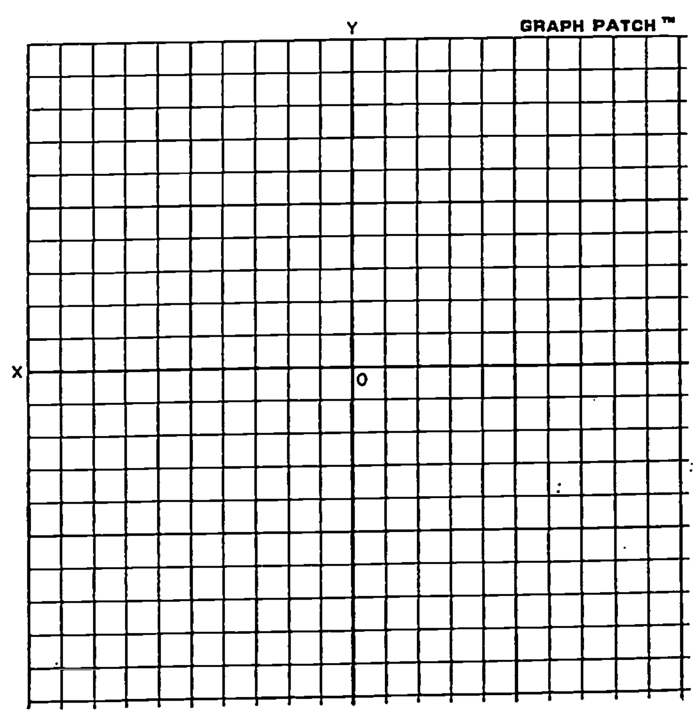
14. Fill in five points on the table that are on your quadratic equation and make a sketch of the graph on the grid provided, showing vertex and x-intercepts.

15. The equation of motion of freely falling bodies is $h = -\frac{1}{2}gt^2 + v_0 t + h_c$, where g is acceleration due to gravity, $v_0$is the initial velocity, and $h_0$is the initial height.

According to your equation, what is the value of g?

The values of b and c are not the initial velocity and height in your regression equation because the first or initial bounce was not used.

Time x	Distance y



16. The velocity of the ball is (change in distance) divided by (change in time). Is the velocity of the ball constant?

17. Use 2nd CALC #6 $\frac{dy}{dx}$ to find the velocity of the ball at several points on the graph. Where is the velocity the greatest? least? Show this on your graph.

18. Run the RANGER program.

19. Choose #4 PLOT MENU, choose #2 VEL-TIME. See the graph in figure 4.
Is that what you expected to find?

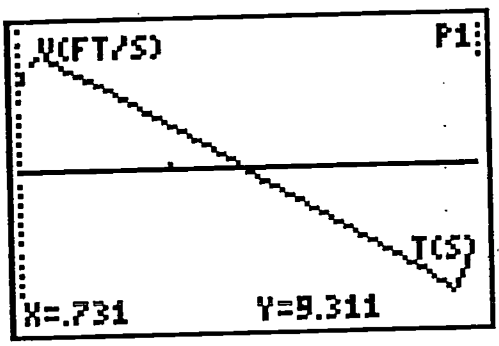


Figure 4

MODELING A DECAYING EXPONENTIAL FUNCTION
USING THE CBR

According to physics textbooks, when a ball is bounced, for a given ball and initial height, the rebound height decreases exponentially for each successive bounce. We are going to test this statement.

Equipment: CBR, TI-82 or TI-83 Calculator, ball, linking cord, level surface.

Procedure:

1. Check the calculator you plan to use to see if it has at least 17,500 bytes of memory available.

   2nd\ Mem \ 1. Check RAM

If you do not have enough memory free, then: **2nd\ Mem\ 5. Reset**
THIS DELETES ALL YOUR PROGRAMS.

2. Connect your calculator to the CBR with the linking cord.
3. Do these keystrokes: **2nd\ Link\ Receive\Enter**
4. Open the pivoting head on the CBR, and press the button that says: **82/83**
5. The calculator will say: **transferring...** When the transfer is complete, the green light on the CBR flashes once, it beeps once, and the calculator says: **done.**
6. The Ranger program has now been transferred to your calculator. Run this program.
7. When the Main Menu is displayed, choose **Applications.**
8. For units, choose **Feet.**
9. Under Applications, choose **3. Ball Bounce.**

Follow directions on screen. You may need to repeat several times, until you get at least 4 good bounces. (See Fig. 1) If you want to use only a portion of your data, go to **Plot Menu\ 4. Plot Tools\ 1. Select Domain.** Follow the directions on the screen to select the portion of your graph you want to use. (See Fig. 2)

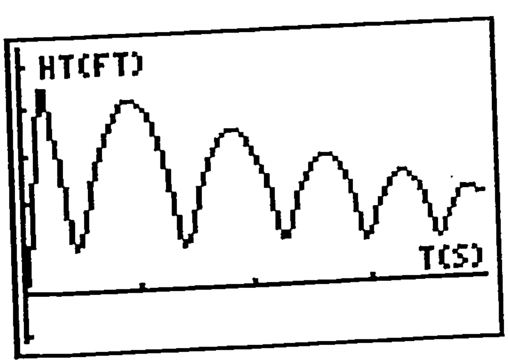


Fig. 1

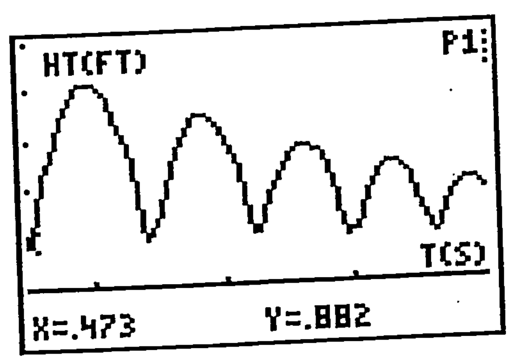


Figure 2

10. Using **Trace,** find the y-coordinate of the highest point of each bounce.

11. Go to **Stat\ Edit** and record the number of the bounce in List 1 and the height of the bounce in List 2. (See Fig. 3)

12. Use **Stat\ Calc\ 0.ExpReg** to find the Exponential Regression Equation for this set of data. (See Fig. 4)

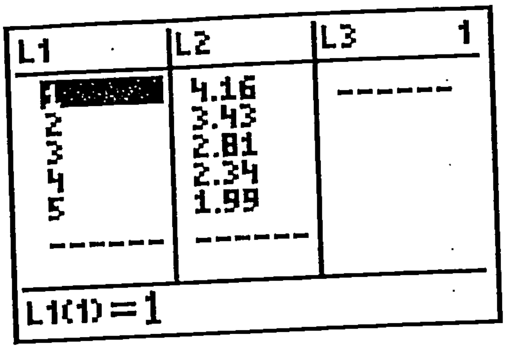


Fig. 3

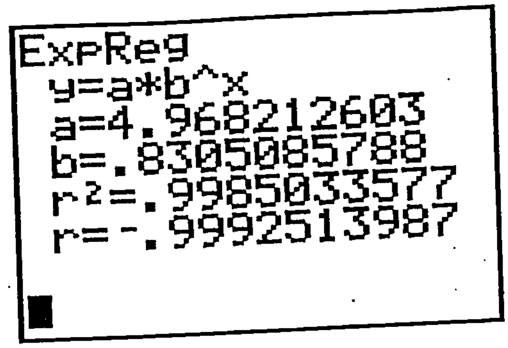


Fig. 4

13. If you wish, you may try other types of regression to see if another might be a better fit. For example, here is the Linear Regression equation. (Fig. 5)

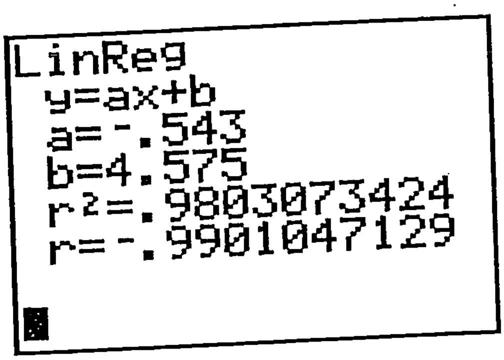


Fig. 5

14. To see the graph of the data, type:**2nd\Stat Plot\1.\Enter\ON\Xlist:L1\Ylist:L2** Then **Zoom 9.** The regression equation may be entered under **Y= .** (See Fig. 6)

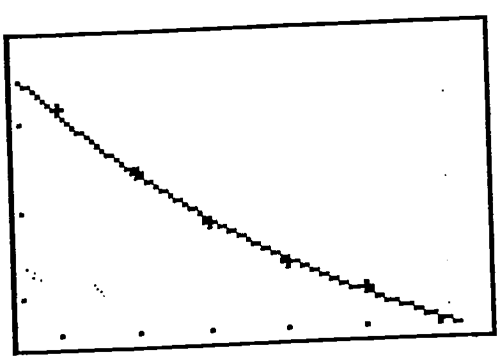


Fig. 6

WORKSHEET

1. Record data in this table:

L1	L2
1	
2	
3	
4	
5	
6	

2. Find the Exponential Regression Equation for your data:

____

r = __________

3. Graph your points and your regression equation.

4. Interpret and predict:

   a) According to your exponential regression equation, from what height was the ball dropped?____________

   b) Each bounce was _______% of the previous bounce.

   c) How high would the ball rebound on the 10th bounce?________

   d) After how many bounces would the ball rebound to a height of 6 inches?

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Signature: Donna Sherrill Peggy Tibbs	Printed Name/Position/Title: Donna Sherrill Math Instructor	PEGGY TIBBS INSTRUCTOR
Organization/Address: ARKANSAS TECH UNIVERSITY RUSSELLVILLE, AR 72801	Telephone: 501-964-0854	FAX:
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